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U.S. PATENT APPLICATION

OF

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FOR

METHOD TO RECOVER BRINE FROM DRILLING FLUIDS

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METHOD TO RECOVER BRINE FROM DRILLING FLUIDS

This application claims the benefit under 35 U.S.C. §119(e) of prior U.S. Provisional Patent Application No. 60/463,021 filed April 15, 2003, which is incorporated in its entirety by reference herein.

BACKGROUND OF THE INVENTION

[0001] The present invention relates to well servicing fluids and drilling fluids. The present invention particularly relates to recovering brine from well servicing fluids or drilling fluids.

[0002] In the oil recovery industry and in hydrocarbon recovery, drilling fluids and well servicing fluids are used on a regular basis. The drilling fluids and other well servicing fluids that are used are either lost during the drilling operation or recovery operation or if recovered, are typically discarded. However, with increasing technology, the drilling fluids either for an environmental reason and/or expense reasons are being recovered for reuse. This is especially true with high tech well servicing and drilling fluids which are quite expensive, and thus their recovery is relatively important since being able to use the well servicing fluids and in particular the brine in the well servicing fluids will greatly reduce the cost of future drilling operations.

[0003] While attempts have been made to recover drilling fluids and purify the brine present in the drilling fluid, these attempts have not met with any great success since drilling fluids are quite difficult to purify due to the many solids and other impurities present in the drilling fluids.

[0004] Accordingly, there is a need in the industry to provide a method to recover brine from drilling fluids so that the brine can be properly discarded and/or reused.

SUMMARY OF THE PRESENT INVENTION

[0005] A feature of the present invention is to provide a method to recover brine from drilling fluids and other well servicing fluids.

[0006] A further feature of the present invention is to provide a method to recover brine using an economically feasible system.

[0007] A further feature of the present invention is to provide a method to recover or purify brine such that the process is not hindered by the many impurities present in the drilling fluid.

[0008] Additional features and advantages of the present invention will be set forth in part in the description that follows, and in part will be apparent from the description, or may be learned by practice of the present invention. The objectives and other advantages of the present invention will be realized and attained by means of the elements and combinations particularly pointed out in the description and appended claims.

[0009] To achieve these and other advantages, and in accordance with the purposes of the present invention, as embodied and broadly described herein, the present invention relates to a method to recover brine from drilling fluids or other well servicing fluids. The method includes filtering the fluid with a rotary vacuum filter to recover at least a portion of the brine in the drilling fluid. The method preferably uses a drum filter as the rotary vacuum filter. The method further preferably involves using a precoat filter media layer on the filter. The method preferably also involves treating the drilling fluid with a filtering aid in order to enhance the recovery of the brine from the drilling fluid.

[00010] The present invention further relates to a method to purify a brine solution using the filtering processes described herein.

[00011] The present invention, in addition, relates to a method to recover brine from

drilling fluids or other well servicing fluids which involves filtering the fluid with a filter system which at least recovers a portion of the brine in the drilling fluid or other well servicing fluids. In this method, the drilling fluid is treated with a filtering aid in order to enhance the recovery of the brine from the drilling fluid. Optionally, the drilling fluid is also heated during the filtering.

[00012] Also, the present invention relates to a method to purify brine in a brine containing solution using the above-described method.

[00013] The present invention also relates to recycled brine, for instance, having a purity level of at least 85% and more preferably a purity level of at least 95% and even more preferably a purity level of at least 99%.

[00014] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are intended to provide a further explanation of the present invention, as claimed.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[00015] The present invention relates to drilling fluids and other well servicing fluids useful in the recovery of oil and other hydrocarbons as well as in any operation using drilling fluids. More particularly, the present invention relates to a method to recover brine from a drilling fluid or other well servicing fluid. Preferably, the drilling fluid is a water-based fluid or mud.

[00016] For purposes of the present invention, brine is a term understood by those skilled in the art of drilling and oil recovery. The brine is typically a salt solution of a particular density used as part of the drilling fluid. Examples of brine include, but are not limited to, formates, acetates, chlorides, bromides, iodides, tungstates, carbonates, bicarbonates, or nitrate salts of ammonium, sodium, potassium, cesium, rubidium, lithium, calcium, magnesium, zinc, or barium. Also, the brine can be a combination or blend of two or more of these salts. More

particular examples of brine, include, but are not limited to, cesium formate, cesium acetate, potassium formate, potassium acetate, and the like. Other examples include calcium bromide, calcium chloride, sodium bromide, calcium nitrate, zinc bromide, cesium tungstate, potassium tungstate, sodium tungstate, and the like.

[00017] Generally, when a drilling fluid is used and recovered, the drilling fluid will contain the brine as well as polymers and other additives. The drilling fluid can also contain solids and other debris that were brought up from the drilling operation. The polymers are typically added to the drilling fluid in order to provide certain desired properties during drilling such as making a highly viscous solution. Examples of the type of materials present in the drilling fluid other than the brine, include, but are not limited to, polysaccharides, such as Xanthan gum, Poly Anionic Cellulose (PAC), starch, Carboxymethyl Cellulose (CMC), AMPS polymers, synthetic polymers, bio-polymers, lignite, cauctised lignite, glycols, esters and other oils, barite, ilmenite, manganese tetroxide, haemetite (weighting agents), bentonite, sepiolite (clays), emulsifiers, surfactants, lime, hydroxides, lubricants, sulphide scavengers, lost circulation material, pipe dope, drill solids, metal swarf, cement, rubber compounds, and the like.

[00018] In addition, the drilling fluid that is recovered, as indicated above, can contain solids and other debris such as cuttings, sand, clays, starch, shale, and other solids recovered from the formation.

[00019] For purposes of the present application, some persons skilled in the art refer to drilling fluids as drilling muds. While some skilled in the art may view drilling fluids to mean something different from a drilling mud, for purposes of the present application, when reference is made to drilling fluids, this includes drilling muds. In addition, other well servicing fluids include, but are not limited to, completion fluids, and other fluids typically

used in hydrocarbon recovery efforts. In order to avoid a listing of each fluid, for purposes of the present application, drilling fluid encompasses drilling muds, completion fluids, drilling fluids, and the like.

[00020] The recovery of the brine from the drilling fluid is even more important when the brine is made from rare or very expensive materials such as cesium based materials. Due to the value of cesium, such as cesium formate or cesium acetate, it is worthwhile to recover the brine from the drilling fluid so that it can be reused.

[00021] The present invention has the ability to recover the majority of the brine present in the drilling fluid and more preferably at least about 85% by weight and even more preferably at least about 95% by weight and even more preferably at least about 99% by weight of the brine originally present in the drilling fluid is recovered by the process of the present invention. More impressive is that the present invention does this in a one-step operation as opposed to multiple steps of purifying which can be quite expensive and timely. Also, as shown below, the present invention can be a mobile operation. In other words, the recovery of the brine or the purification of the brine can occur at the drilling site or at a site nearby (e.g., on a ship, floating dock, drilling rig, floating vessel etc…). In the alternative, the filtering operation of the present invention can be mobile and thus occur at any location even on a ship or at a floating well site and the like, thus making the process of the present invention very useful, cost effective, and efficient.

[00022] With respect to the method of the present invention, one method involves recovering brine from a drilling fluid or other well servicing fluid. The method includes filtering the fluid with a rotary vacuum filter (e.g., continuous) to recover at least a portion of the brine in the drilling fluid or other well servicing fluid. The rotary vacuum filter can be a drum filter, a disc filter, a horizontal belt filter, a horizontal scroll discharge, a horizontal

tipping pan, or the like. The rotary vacuum filter that can be used in the present invention can be obtained from such manufacturers as Immair of Milan, Italy. Other manufacturers include Dorr Oliver, VanPipe, and Stockdale.

[00023] The filtering surface can be any size depending upon the scale of the recycling operation of the brine. The filtering surface can be 0.1 m^2 to 80 m^2 or higher. Typically, a holding tank containing the used drilling fluids or other well servicing fluids is present. A pipe is then used to pump the drilling fluid to the rotary vacuum filter which contains a basin to hold the drilling fluid while the filtering is occurring with the rotary vacuum filter. The recovered brine that is passing through the vacuum filter to the inside of the rotary vacuum can then be ultimately pumped to a holding tank for subsequent treatment if desired.

[00024] Examples of suitable vacuum filter systems for purposes of the present invention include those described in U.S. Patent Nos. 4,816,169; 4,618,424; 4,211,653; 4,083,767; 6,500,347; 6,355,167 and 6,190,551 and U.S. Patent Application Publication No. 2002/0008061 A1, all incorporated in their entirety by reference herein. All publications and patents mentioned throughout the present application are incorporated in their entirety herein by reference and form a part of the present application.

[00025] A filter cloth or other similar material is preferably present on the vacuum filter, such as the drum filter. This filter cloth can be polypropylene or other types of polymer or non-polymer materials (e.g., polyethylene, vinyl, natural materials, activated carbon, fiberglass). The pore size of the filter cloths should be sufficient to prevent any precoat filter media that is optionally used from entering the internal surface area of the filter such as the drum filter. In the present invention, the pore size of the filter cloth is preferably from about 75 microns to about 90 microns.

[00026] In the present invention, a precoat filter media layer is preferably present on the

vacuum filter, such as on the filter cloth. The precoat filter media is the primary layer that permits the filtration of the brine from the remaining aspects of the drilling fluids such as the solid and debris as well as the polymers, that may be present in the drilling fluid or other well servicing fluid. The precoat filter media layer can be any suitable thickness such as from about 1 cm thick or less to about 15 cm thick or more. The thicker the precoat filter media layer, the longer the filtration process can be continuously run. The precoat filter media layer typically is formed by forming a slurry of the ingredients that form the filter media layer and then rotating the drum continuously through the slurry to slowly build up a layer of the precoat filter media. The precoat filter media layer can contain diatomaceous earth, perlite, cellulose, or combinations thereof. Specific examples of the filter media include Perlite CP1400E and Celatom FW60 from Celatom Division. The particle size can be any suitable size, such as a median particle diameter of from 30 microns to 60 microns.

[00027] In one embodiment, the filter, such as the drum filter, is rotated during the filtration process such that the drum filter is partially submerged in the drilling fluid. During filtering, most, if not all, of the solids present in the drilling fluid are retained on the surface of the precoat filter media layer. As the solids build up on the precoat filter media layer, the solids can be removed by any means to expose a fresh surface of the filter media layer such that the filtration can continuously occur. These solids can be removed, for instance, with a knife blade and can occur on a continuous basis. For instance, the knife blade can move at a rate of from about 0.005 mm to about 100 mm or higher per hour. (The knife blade can also move in steps, one step in for each rotation of the drum, at an equivalent rate as given above) This is with reference to the depth of the knife blade. In other words, the knife blade can be slowly lowered to carefully remove just the upper portion of the precoat filter media layer. Other rates are, of course, possible. The removing of the solids and a very slight portion of the

precoat filter media layer ensures that the solids removed from the drilling fluid do not interfere with further filtration and the removal of the solids can be collected from the drilling fluid and discarded.

[00028] In another embodiment of the present invention, the drilling fluid that is being filtered can be heated above ambient temperature prior to and/or during the filtering. Preferably, the drilling fluid is heated to a temperature of at least about 20° C and more preferably at least about 50° C. A suitable temperature range, for instance, can be from about 20° C to about 180° C or higher. Heating the drilling fluid to these elevated temperatures enhances the recovery efforts of the brine during the filtration process.

[00029] In another embodiment of the present invention, the method can include treating the drilling fluid with at least one filtering aid. The filtering aid can contain at least one alkali metal hydroxide or polyelectrolyte or both and/or lime. Examples of the filtering aid include, but are not limited to, sodium hydroxide, potassium hydroxide, and the like as well as combinations thereof. Examples of polyelectrolytes include, but are not limited to, iron salt, aluminum salt, cationic polymer flocculants, anionic polymer flocculants, or combinations thereof. The filtering aid can be used in any amount to enhance the recovery of the brine from the drilling fluid. Examples of suitable amounts include from about 0.1 kiloliter to about 35 kiloliters or more per m^3 of the drilling fluid. The filtering aid can be a solid or liquid and can be introduced to the drilling fluid prior to the filtration or during the filtration. The filtering aid preferably has the ability to cause flocculation of any polymers or other materials present in the drilling fluid and/or precipitate the polymers and other materials from the drilling fluid in order to enhance the filtration and purification of the brine in the drilling fluid or other well servicing fluids.

[00030] During the rotary vacuum filter operation, the filter, such as the drum filter, can be

rotated at any suitable speed, such as from about 0.05 to about 5 rpm or more. During the rotary vacuum operation, a vacuum is preferably applied to the inside of the filter such as the drum filter, to draw the brine present in the drilling fluid through the precoat filter media in order to separate the brine from the drilling fluid. The amount of vacuum can vary, and for instance can be more than or less than –0.8 bar. The solids and polymers and other non-brine materials, for instance, are preferably removed and remain as a coating on the surface of the precoat filter media layer. As indicated above, the brine passes through the precoat filter media layer for recovery. The brine can be collected into a tank as indicated above. With respect to substantially removing the polymers and solids from the drilling fluid, preferably, the purity of the recovered brine solution is at least about 75% and more preferably at least about 85% and more preferably at least about 90%, or at least 95%, or at least about 99% pure brine.

[00031] In another embodiment of the present invention, the method can include spraying the outside surface of the filter, such as the drum filter, with water (or dilute brine). Spraying with water can enhance further recovery of the brine that may be saturated on the precoat filter media layer. This spraying of the outer surface can be done by any means such as with a spray arm or wand or the like. The spraying can be done with a light mist of water.

[00032] Once the brine is separated from the drilling fluid, and if a filtering aid is used, the pH of the brine can be relatively high such as on the order of 13 or 14. In another embodiment of the present invention, a pH agent can be added to the brine at this point to lower the pH. For instance, the pH can be lowered to a pH of about 7 to about 12. Any pH reducing agent can be used such as acids, such as formic acid, or bicarbonates can be used. The amount of pH reducing agent added would be sufficient to achieve the desired pH such as described above.

[00033] Besides removing solids and debris from the drilling fluid as described above, an

additional embodiment and benefit of the present invention is the ability of the present invention to remove oil contamination from the drilling fluid. In addition, the waste material recovered from the drilling fluid can, in an additional embodiment of the present invention, be washed with an aqueous solution such as water to recover additional brine from the waste material. The wash water from the washing of the waste material can then be filtered by any means such as through the use of the rotary vacuum filter described above or other filtering means. Also, this filtered wash water can then be placed in an evaporator or other means to remove excess water to obtain the desired brine density. Also, drill cuttings can also be subjected to such a washing to recover drilling fluid and then to recover the brine from the drilling fluid as described above.

[00034] The fluids and components thereof and other details as set forth in WO 02/079089; WO 96/31435; WO 03/018708; GB 2,304,354; U.S. Published Patent Application Nos. 2002-0117457; 2002-160919; 2003-004068; and 2002-036088; and U.S. Patent Nos. 6,436,879; 6,518,223; 5,620,947; 6,536,540; 6,403,537; and 6,391,830, can be used in the present invention and/or can benefit from the present invention, and these patents, patent applications, and publications mentioned here and throughout are incorporated in their entirety by reference herein.

[00035] The above processes can equally be applied to brine solutions in general. In other words, a brine solution can be purified by the above methods even though the brine solution may not be considered a drilling fluid or well servicing fluid. The same steps as described above can be used.

[00036] In addition, the present invention relates to a process to recover brine from drilling fluids wherein the process involves treating the fluid or brine containing solution with a filtering aid, as described above, and then filtering the fluid using any filtering system, such as

described above or other filtering systems, such as membranes, centrifuges, paper filters, and the like. This process can also include heating the brine containing solution or drilling fluids as described above and further can include the post treatment with a pH agent as described above.

[00037] The present invention further relates to a well servicing fluid or drilling fluid which contains the recycled brine. The recycled brine preferably has a purity as described above of at least 75% or higher and more preferably at least about 95% or at least about 99%. The recycled brine preferably is cesium formate or cesium acetate or other cesium salts or a combination thereof. The recycled brine can further contain other conventional ingredients used in well servicing fluids or drilling fluids such as, but not limited to, polymers, lignite, cauctised lignite, glycols, esters and other oils, barite, ilmenite, manganese tetroxide, haemetite (weighting agents), bentonite, sepiolite (clays), emulsifiers, surfactants, lime, hydroxides, lubricants, sulphide scavengers, lost circulation material, pipe dope, drill solids, metal swarf, cement, rubber compounds, and the like

[00038] The present invention will be further clarified by the following examples, which are intended to be purely exemplary of the present invention.

EXAMPLES

[00039] In one trial on a rotary vacuum filter unit with a surface area of 0.80 M^2, contaminated brine containing 14.5% Vol / Vol solids was filtered at ambient temperature. Filtration rates of between 70 and 100 litres an hour were achieved and a recovery rate of 84% of the brine was achieved. In this trial the filtering medium was Perlite.

[00040] In a second trial on a rotary vacuum filter unit with a surface area of approximately 18 M^2, used drilling fluid was filtered to recover the brine phase. The drilling fluid was pre-treated with 5 lbs per barrel of solid potassium hydroxide. The drilling Fluid contained

aproximately 4.5% V/V solids. The filter media used was perlite for the first run and diatomaceous earth for the second run. For the first run the drilling fluid was applied at ambient temperature and later heated to approximately 50 deg C and for the second run the drilling fluid was at ambient temperature. Filtration rates varied between 5 and 20 bbls per hour. The application of heated drilling fluid increased the flow rates compared with the drilling fluid at ambient temperature. Increasing the drum rotation speed was found to increase the filtration rate, increasing knife advance speed also increased filtration rate to a point, where increased knife speed had no additional effect. The moisture content of the waste discharge from the knife blade was found to decrease with increasing temperature indicating improved efficiency. Moisture content was also found to be lower when diatomaceous earth was used compared with the perlite. Typically moisture content varied between 19 % W/W and 32 % W/W of the waste discharge. Brine reclamation efficiency during this trial varied between 85% and 95% recovery of the brine phase.

[00041] Other embodiments of the present invention will be apparent to those skilled in the art from consideration of the present specification and practice of the present invention disclosed herein. It is intended that the present specification and examples be considered as exemplary only with a true scope and spirit of the invention being indicated by the following claims and equivalents thereof.